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Indian Standard

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मोटर वाहनों के लिए सीसा अम्ल की भंडारण बैटरियाँ — वाल्व रेगुलेटेड टाइप

Lead Acid Storage Batteries for Motor Vehicles — Valve Regulated Type

ICS 29.220.20

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Secondary Cells and Batteries Sectional Committee, ET 11

FOREWORD

This Indian Standard was adopted by the Bureau of Indian Standards, after the draft finalized by the Secondary Cells and Batteries Sectional Committee had been approved by the Electrotechnical Division Council.

This standard covers Specifications of valve regulated type — Lead acid batteries for motor vehicles.

While formation of this standard, assistance has been derived from IEC 60095-1 (2006) 'Lead-acid starter batteries — Part 1: General requirements and methods of test', issued by the International Electrotechnical Commission.

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis shall be rounded off in accordance with IS 2 : 1960 'Rules for rounding off numerical values (*revised*)'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

Indian Standard

LEAD ACID STORAGE BATTERIES FOR MOTOR VEHICLES — VALUE REGULATED TYPE

1 SCOPE

This standard specifies general requirements, essential functional characteristics, relevant test methods and results required for stationary valve regulated lead acid (VRLA) batteries with a nominal voltage of 12V, used primarily as a power source for the starting of internal combustion engines, lighting and for auxiliary equipment of internal combustion engine vehicles. These batteries are commonly called "starter batteries"

1.1 Classification and Designation of Starter Batteries — Open Circuit Voltage

1.1.1 *Battery Classification According to Application*

Three classes of batteries are defined according to their application, as follows:

a) *Class A* — Batteries for starter applications with usual cycling capability and normal mechanical resistance;
b) *Class B* — Batteries for starter applications which have an important higher requirement in cycling ability and/or mechanical resistance; and
c) *Class C* — Batteries for starter applications and high temperature duty.

1.1.2 *Battery Designation According to Type*

Valve-regulated (with gas recombination) battery: a valve-regulated battery is a secondary battery that is closed under normal conditions and has an arrangement that allows the escape of gas if the internal pressure exceeds a predetermined value. The battery cannot normally receive an addition of water or electrolyte. In this type of battery, the electrolyte is immobilized.

1.1.3 *Open Circuit Voltage*

The open circuit voltage (OCV) at 27°C, of fully charged batteries after a minimum 24 h stand on open circuit, shall be 12.80 V minimum for valve regulated types unless otherwise specified by the manufacturer.

2 CONDITION OF DELIVERY

Batteries are normally supplied in a state ready for use.

3 GENERAL REQUIREMENTS

3.1 Marking

The following informations shall be durably marked on each battery:

3.1.1 *Manufacturers Name*

3.1.2 *Class of Battery*: A, B or C (*see* **1.1.1**)

3.1.3 *Nominal Voltage*: 12V

Nominal Cranking Current: I_{cc} (A) (*see* **4.1.1**)

3.1.4 Capacity (*see* **4.1.2**)

- — either 20 h capacity C_n (Ah)
- — or reserve capacity $C_{r,\,n}$ (min)

3.1.5 *Safety Labelling*

Batteries shall be marked with the six coloured symbols as described in Annex B.

3.1.6 *Country, Month and Year of Manufacture*

3.1.7 *BIS Certification Marking*

The batteries may also be marked with the Standard Mark.

The use of the Standard Mark is governed by the provisions of the *Bureau of Indian Standards Act*, 1986 and the Rules and Regulations made thereunder. The details of conditions under which the licence for the use of the Standard Mark may be granted to manufacturers or producers may be obtained from the Bureau of Indian Standards.

4 FUNCTIONAL CHARACTERISTICS

4.1 Electrical Characteristics

4.1.1 The cranking performance is the discharge current I_{CC}, as indicated by the manufacturer, which a battery can supply according to **6.3**.

4.1.2 The capacity of a starter battery is defined for a temperature of 25°C ± 2°C.

It may be indicated by the manufacturer as either:

- — nominal 20 h capacity C_n or

— Nominal reserve capacity $C_{r,n}$

The 20 h nominal capacity C_n is the electric charge in ampere hours (Ah) that a battery can supply with a current:

$$I_n = \frac{C_n}{20}\ (A)$$

Until the terminal voltage falls to U_f = 10.50 V.

The effective 20 h capacity C_e shall be determined by discharging a battery with constant current I_n to U_f = 10.50 V (*see* **6.1**). The resultant discharge time, in hours, is used for the verification of C_n.

The nominal reserve capacity $C_{r,n}$ is the period of time (in minutes) for which a battery can maintain a discharge current of 25A to a cut-off voltage U_f = 10.50 V.

The effective reserve capacity $C_{r,e}$ shall be determined by discharging a battery with the constant current I = 25A to U_f = 10.50 V (*see* **6.2**). The resultant discharge time, in minutes, is used for the verification of $C_{r,n}$.

NOTE — For the correlation (relationship) of C_n and $C_{r,n}$ (*see* Annex A).

4.1.3 The charge acceptance is expressed as the current I_{ca} which a partially discharged battery accepts at 0°C and a constant voltage of 14.40 V.

4.1.4 The charge retention is defined as the cold cranking performance of the charged and filled battery after storage on open circuit under defined conditions of temperature and time (*see* **6.5**).

4.1.5 Endurance test consists of two parts.

4.1.5.1 Corrosion test represents the ability of a battery to perform repeated overcharge/storage periods (*see* **6.6**).

4.1.5.2 Cycling test represents the ability of a battery to perform repeated discharge/recharge cycles and long rest periods on open circuit. This ability shall be tested by a series of cycles and rest periods under specified conditions after which the cold cranking or the capacity performances shall be determined (*see* **6.6**)

4.2 Mechanical Characteristics

4.2.1 Vibration resistance represents the ability of a battery to maintain service under periodic or irregular acceleration forces. Minimum requirements shall be verified by a test (*see* **6.7**).

4.2.2 Electrolyte retention is the ability of a battery to retain the electrolyte under specified physical conditions (*see* **6.8**).

5 GENERAL TEST CONDITIONS

5.1 Sampling of Batteries

All tests shall be carried out on new battery samples. Samples shall be considered as "new" not later than 30 days after shipment date of manufacturer.

5.2 Preparation of Batteries Prior to Test — Definition of a Fully Charged Battery

All tests shall commence with fully charged batteries

Batteries shall be considered as fully charged if they have undergone one of the two charging procedures of **5.2.1** and **5.2.2** carried out at 25°C ± 10°C. If necessary, an appropriate temperature control system, for example a water bath, shall be used.

5.2.1 *Charging of Valve Regulated Batteries at Constant Current (Two Step Method)*

The battery shall be charged:

- at a constant current of 2 I_n (*see* **4.1.2**) until the voltage reaches 14.40V;
- then at a constant current of I_n for 4 h.

5.2.2 *Charging of Valve Regulated Batteries at Constant Voltage and Constant Current (Two Step Method)*

The battery shall be charged:

- at a constant voltage of 14.40 V ± 0.10V for 20 h with the maximum current limited to 5 I_n (*see* **4.1.2**),
- then with a constant current of 0.5 I_n for 4 h

NOTE — If neither complete knowledge of the battery construction nor a specification from the manufacturer is available, then charging according to the present (*see* **5.2.2**), is recommended.

5.3 Measuring Instruments

5.3.1 *Electrical Measuring Instruments*

The range of instruments used shall be appropriate for the magnitude of the voltage or current to be measured.

- *Voltage measurement*:

  The instruments used for measuring voltages shall be digital voltmeters having an accuracy of ±0.04V or better.

- *Current measurement*:

  The instruments used for current measurement shall be digital ammeters having an accuracy of 1.0 percent or better. The assembly of ammeter, shunt and leads shall have an overall accuracy of 1.0 percent or better.

5.3.2 *Temperature Measurement*

The thermometers used for measuring temperature shall have an appropriate range, and the value of each scale division shall not be greater than 1K. The accuracy of the calibration of the instruments shall be not less than 0.5 K.

5.3.3 *Time Measurement*

The instruments used for measuring time shall be graduated in hours, minutes or seconds. They shall have an accuracy within ±0.1 percent in all cases with the exception of cranking performance tests where the times measured in seconds shall have an accuracy within ±1.0 percent.

5.4 Test Sequence

5.4.1 *Batteries Filled and Charged*

The tests according to Table 1 shall be carried out only if batteries have complied with the previous tests, and not later than one week after completion of the first part.

Table 1 Test/Battery

(*Clause* 5.4.1)

Test		Battery					
		1	2	3	4	5	6
20 h Capacity	Reserve capacity	X	X	X	X	X	X
Cranking performance		X	X	X	X	X	X
Endurance Tests (**6.6**)	Corrosion test	X					
	Cycling test		X				
Charge retention (**6.5**)					X		
Charge acceptance (**6.4**)				X			
Electrolyte retention (**6.8**)					X		
Vibration resistance (**6.7**)						X	

6 TEST METHODS

6.1 Twenty hour Capacity Check, C_e

6.1.1 Throughout the duration of the tests, the battery shall be placed in a water bath at a temperature of 25°C ± 2°C. The terminal base of the battery shall be at least 15 mm but no more than 25 mm above the level of the water. If several batteries are in the same water bath then the distance between them and also the distance to the walls of the bath shall be at least 25 mm.

6.1.2 The battery shall be discharged with the current I_n (calculated according to **4.1.2**) kept constant at ±2 percent of the nominal value until the terminal voltage falls to 10.50 V ± 0.05 V. The duration t(h) of the discharge shall be recorded. The beginning of the discharge shall take place between 1 h to 5 h after the completion of charging according to **5.2**.

The battery terminal temperature, measured shall be 25°C ± 2°C before the discharge begins.

6.1.3 The capacity C_e is as follows:

$$C_e = t \times I_n \text{ (Ah)}$$

If the final battery temperature is different from 25°C ± 2°C the following temperature correction formula shall be used:

$$C_e 25^\circ\text{C} = C_{eT} [\ 1\%\ 0.01(T\%\ 25)]$$

6.1.4 *Requirement* (*see* **7**).

6.2 Reserve Capacity Check $C_{r,\,e}$

6.2.1 Throughout the duration of the tests, the battery shall be placed in a water bath at a temperature of 25°C ± 2°C. The terminal base of the battery shall be at least 15 mm but no more than 25 mm above the level of the water. If several batteries are in the same water bath then the distance between them and also the distance to the walls of the bath shall be at least 25 mm.

6.2.2 The battery shall be discharged with a current 25 A ± 1 percent until the terminal voltage falls to 10.50 V ± 0.05 V. The duration t (in minutes) of the discharge shall be recorded. The beginning of the discharge shall take place between 1 h to 5 h after the completion of charging according to **5.2**.

NOTE — The battery terminal temperature, measured shall be 25°C ± 2°C before the discharge begins.

$$C_{r,\,e} = t \text{ (min)}$$

If the final battery temperature is different from 25°C ± 2°C the following temperature correction formula shall be used:

$$C_{r,\,e} 25^\circ\text{C} = C_{r,\,eT} [1 — 0.009 (\text{T} — 25)]$$

6.2.3 *Requirement* (*see* **7**)

6.3 Cranking Performance Test

6.3.1 *Cranking Performance Test — Standard Temperature*

6.3.1.1 After a rest period of up to 24 h, the battery shall be placed in a cooling chamber with (forced) air circulation at a temperature of –18°C ± 1°C until the battery terminal temperature has reached –18°C ± 1°C

NOTE — It is generally accepted that the required temperature will be achieved after a minimum period of 24 h in the cooling chamber.

6.3.1.2 The battery shall then be discharged, either within or outside the cooling chamber, within 2 min after the end of the cooling period with a current I_{cc} (*see* **4.1.1**). This current shall be kept constant to within ± 0.5 percent during the discharge.

6.3.1.3 After 10 s discharge, the terminal voltage U_{f10s} shall be recorded. After 30 s discharge, the terminal voltage U_{f30s} shall also be recorded and the current shall be cut off.

NOTE — **6.3.1.1** to **6.3.1.3** comprise stage 1 of the cranking performance test.

6.3.1.4 The test shall be continued after a rest time of 20 s ± 1s.

6.3.1.5 The battery shall then be discharged at 0.6 I_{cc}. The current shall be kept constant to within ± 0.5 percent during the discharge. The discharge shall be terminated when the battery voltage reaches 6V.

6.3.1.6 The discharge time (t_6V), in seconds, at 0.6 I_{cc} to 6V shall be recorded.

NOTE — **6.3.1.4** to **6.3.1.6** comprise stage 2 of the cranking performance test.

6.3.2 *Cranking Performance Test — Very Cold Climates*

This test shall be performed only if the battery is specified for very cold climate application by the manufacturer.

The test method is the same as defined above for the standard temperatures with

- cooling chamber temperature = –29°C ± 1°C; and
- I_{cc} for very cold climate rated on the battery label by the manufacturer.

6.3.3 *Requirement*: (*see* **7**)

6.4 Charge Acceptance Test

6.4.1 The test shall be carried out on batteries which have been charged in accordance with **5.2.2**.

6.4.2 The battery shall be placed in a water bath at a temperature of 25°C ±2°C. The terminal base of the battery shall be at least 15 mm but no more than 25 mm above the level of the water. If several batteries are in the same water bath then the discharge between them and also the distance to the walls of the bath shall be at least 25 mm.

6.4.3 The battery shall be discharged at a current I_o :

$$I_o = Ce_{20} / 10 \text{ h (A) for 5 h}$$

The value C_e shall be taken according to **6.1**.

6.4.4 Immediately after the discharge, the battery shall be cooled at a temperature of 0°C ± 1°C for a minimum of 20 h or until the battery terminal temperature has reached 0°C ± 1°C

6.4.5 At this temperature of 0°C ± 1°C, the battery shall be charged at a constant voltage of 14.40 V ± 0.10 V. After 10 min, the charging current I_{ca} shall be recorded.

6.4.6 *Requirement* (*see* **7**).

6.5 Charge Retention Test

6.5.1 A fully charged battery (according to **5.2**), with its vent plugs firmly in place and a clean dry surface, shall be stored at 40°C ±2°C on open circuit for a period of 49 days. No connecting clamps or cables shall be attached to the terminals.

6.5.2 After this storage period, the battery shall be submitted, without recharge, to a cranking performance test at –18°C and a current $I = 0.6 I_{cc.}$ The voltage after 30 s (U_{30s}) shall be recorded.

6.5.3 *Requirement* (*see* **7**).

6.6 Endurance Test for Batteries

6.6.1 *Corrosion Test*

6.6.1.1 The test shall be carried out on fully charged batteries in accordance with **5.2.2** but with the times of the constant voltage charge being limited to 10 h.

6.6.1.2 The battery shall be placed in a water bath maintained at a temperature of 60°C ± 2°C. The terminal base of the battery shall be atleast 15 mm but not more than 25 mm above the level of the water. If several batteries are in the same water bath then the distance between them and also the distance to the walls of the bath shall be atleast 25 mm.

6.6.1.3 The battery, maintained at 60°C ± 2°C, shall be charged at a constant voltage of 14.00 V ± 0.10 V for a period of 13 days.

6.6.1.4 The battery shall be stored on open circuit, still at 60°C ± 2°C, for a period of 13 days. No connecting clamps or cables shall be attached to the terminals.

6.6.1.5 The battery shall be cooled to reach 25°C ± 2°C.

6.6.1.6 The battery shall then be recharged in accordance with **5.2.2** but with the times of the constant voltage charge being limited to 6 h.

6.6.1.7 the battery, maintained at 25°C ± 2°C, shall be stored for a rest period of 20 h.

6.6.1.8 The battery shall be discharged with a current of 0.6 I_{cc} at 25°C ± 2°C for 30s. The 30s voltage shall be recorded.

6.6.1.9 The sequence **6.6.1.1** to **6.6.1.8** constitutes one corrosion test unit.

6.6.1.10 The whole sequence **6.6.1.1** to **6.6.1.8** shall be repeated and the test shall be terminated when the battery voltage reaches less than 7.2 V at 30s with a current of $0.6I_{cc}$ in cranking test at 25°C ± 2°C (*see* **6.6.1.8**).

6.6.1.11 *Requirements — Number of Units* (*see* **7**).

6.6.2 *Cycling Test 1*

6.6.2.1 Test shall be carried out on fully charged batteries in accordance with **5.2**.

6.6.2.2 Throughout the whole test period, with the exception of the rapid discharge test at the temperature of –18°C ± 1°C, the battery shall be placed in a water bath at a temperature of 25°C ± 2°C. The terminal base of the battery shall be at least 15 mm but not more than 25 mm above the level of the water. If several batteries are in the same water bath then the distance between them and also the distance to the walls of the bath shall be at least 25 mm.

6.6.2.3 The batteries shall be connected to a device where they undergo a series of discharge/charge cycles for a required number of cycles, each cycle comprising:

a) a discharge for 1 hour at a current, in amperes, of $I = 5\ I_n$,

b) Immediately followed

  — by a recharge for 2h and 55 min at a voltage of 14.40 V ± 0.10 V or 14.80 V ± 0.10 V (according to the manufacturer recommendation) with a maximum current in amperes being limited to $I_{Max} = 10\ I_n$ (*see* **4.1.2**), and

  — for 5 min at a constant current, in amperes, of $I = 0.5\ I_n$

6.6.2.4 The test shall be terminated if the battery voltage drops below 10.50 V during the discharge prior to completion of the required number of cycles (*see* **7**).

6.6.2.5 When the cycling is over, the battery shall be placed in a cooling chamber with (forced) air circulation at a temperature of –18°C ± 1°C for a minimum of 20 h or until the battery terminal temperature has reached –18°C ± 1°C.

6.6.2.6 The battery shall then be discharged after the end of the cooling period with a current $0.6I_{cc}$.

6.6.2.7 After 30 s of discharge, the voltage across the battery terminals shall be measured. It shall not be less than 7.20 V. The discharge shall then be terminated.

6.6.2.8 *Requirements — Number of cycles* (*see* **7**)

6.6.3 *Cycling Test 2*

6.6.3.1 The test shall be carried out on batteries that have been charged in accordance with **5.2.2**.

6.6.3.2 Throughout the whole test period, with the exception of the rapid discharge test at the temperature of –18°C ± 1°C, the battery shall be placed in a water bath at a temperature of 25°C ± 2°C. The terminal base of the battery shall be at least 15 mm but not more than 25 mm above the level of the water. If several batteries are in the same water bath then the distance between them and also the distance to the walls of the bath shall be atleast 25 mm.

6.6.3.3 The batteries shall be connected to a device where they undergo a series of 18 cycles, each cycle comprising:

a) A discharge for 2 h at a current, in amperes, of $I = 5\ I_n$,

b) Immediately followed

  — by a recharge for 4 h and 45 min at a voltage of 14.40 V ± 0.10 V or 14.80 V ± 0.10 V (according to the manufacturer recommendation) with a maximum current in amperes being limited to $I_{max} = 5\ I_n$ (*see* **4.1.2**), and

  — for 15 min at a constant current in amperes of $I = 0.5\ I_n$

6.6.3.4 The battery, maintained at 25°C ± 2°C shall be charged in accordance with 5.2.2 but with the times at constant voltage charge being limited to 6 h.

6.6.3.5 The battery shall then be stored on open circuit, still at 25°C ± 2°C for 5 h.

6.6.3.6 The battery shall then be discharged at $I = 5\ I_n$ down to 10.00 V ± 0.05 V (capacity:C).

6.6.3.7 The battery shall then be recharged in accordance with **5.2.2**.

6.6.3.8 The sequence **6.6.3.2** to **6.6.3.7** constitutes one cycling test unit.

6.6.3.9 The whole sequence **6.6.3.2** to **6.6.3.7** shall be repeated to the required number of units. The actual capacity at the end of the last unit shall be $C \geq 0.5\ C_n$

6.6.3.10 If the criteria $C \geq 0.5\ C_n$ is achieved, the battery shall be placed in a cooling chamber with (forced) air circulation at a temperature of –18°C ± 1°C for a minimum of 20 h or until the battery terminal temperature has reached –18°C ± 1°C.

6.6.3.11 The battery shall then be discharged after the end of the cooling period with a current of $0.6I_{cc.}$

6.6.3.12 After 30 s of discharge, the voltage across the battery terminals shall be measured. It shall not be less than 7.20 V. The discharge shall then be terminated.

6.6.3.13 *Requirements — Number of units* (*see* **7**).

6.6.4 *Cycling Test 3 (Applicable to Batteries with C_r from 40 min to 150 min)*

6.6.4.1 The test shall be carried out on batteries that have been charged in accordance with **5.2.2**.

6.6.4.2 Throughout the whole test period, the battery shall be placed in a water bath at a temperature of 40°C ± 2°C (or 75°C ± 3°C). The terminal base of the battery shall be at least 15 mm but not more than 25 mm above the level of the water. If several batteries are in the same water bath then the distance between them and also the distance to the walls of the bath shall be at least 25 mm.

6.6.4.3 The batteries shall be connected to a device where they undergo a continuous series of cycles, each cycle comprising:

a) a discharge for 240 s ± 1s at 25A ± 0.1 A
b) Followed, within 10s, by a charge for 600s ± 1 s at the maximum charge current of 25 A ± 0.1 A with a maximum charge voltage of 14.80 V ± 0.03V, with the interval between the charge and the discharge periods not exceeding 10 s, for 100 h $^{+12}_{-0}$ h.

6.6.4.4 The battery, maintained at the temperature chosen in **6.6.4.2**, shall be stored on open circuit for between 65 h – 70 h.

6.6.4.5 With the battery at the temperature selected in **6.6.4.2**, discharge at I_{cc} cranking amps for 30 s. The terminal voltage at 30 s (U_{30s}) shall be recorded together with the number of cylces described in **6.6.4.3**.

6.6.4.6 The battery should be replaced on the cycling test without a separate charge, starting on the "charge" portion 'b' of the cycle.

6.6.4.7 The cycling test should be considered complete when the terminal voltage at 30 s (U_{30s}) of **6.6.4.5** falls to below 7.20 V. The number of cycles shall be determined by plotting the 30s (U_{30s}) voltage values versus the cycle values. The point where the line crossing 7.20V shall be the cycle reported for that battery.

6.6.4.8 *Requirements* — Number of Cycles (*see* **7**).

6.6.5 *Endurance Test Sequence*

According to their classification, batteries are submitted to the test sequence defined in Table 2.

Table 2 Endurance Test Sequence

(*Clause* 6.6.5)

Battery Class Test	I	II
Corrosion	X	X
Cycling 1 or 3 (40°C)	X	
Cycling 2		X

6.7 Vibration Resistance Test

6.7.1 After charging according to **5.2**, the battery shall be stored for 24 h at a temperature of 25°C ± 2°C.

6.7.2 The battery shall be fastened rigidity to the table of the vibration tester. The fastening shall be of the same type as that used on a vehicle and secured by either

— the bottom hold-downs or ledges on the lower part of the container and suitable hold-down clamps and bolts with M8 thread, tightened to a torque of between 15 Nm and 25 Nm, or

— An angle-iron frame covering the upper edges of the battery case/cover assembly for a minimum width of X mm (*see* Table 3), connected to the vibration table by four screwed rods with M8 thread, tightened to a torque of between 8 Nm and 12 Nm.

6.7.3 The battery shall be subjected for a period of *T*(h) (*see* Table 3) to a vertical vibration of a frequency of 30 Hz ± 2 Hz, these vibrations being as nearly sinusoidal as possible.

The maximum acceleration on the battery shall reach the value *Z* (*see* Table 3).

NOTE — The battery temperature throughout the vibration shall be between 20°C and 30°C.

6.7.4 After a maximum of 4 h after the end of the vibration, the battery shall be subjected, without recharge, to a discharge at a temperature of 25°C ± 2°C with a current $I = I_{cc.}$

The terminal voltage after 30 s ($U_{30\ s}$) discharge shall be recorded. The discharge shall then be terminated.

Table 3 Values for Vibration Resistance Test

(*Clauses* 6.7.2.*and* 6.7.3)

	Battery Class	
	A, C	B
X	15 mm	33 mm
T	2 h	8 h
Z	30 ms^{-2} ± 1 ms^{-2}	50 ms^{-2} ± 1 ms^{-2}

6.7.5 *Requirement* (*see* **7**)

6.8 Electrolyte Retention Test

6.8.1 After charging according to **5.2**, the battery shall be stored for 4 h on open circuit at a temperature of 25°C ± 2°C.

6.8.2 The battery shall then be tilted in each of the four directions at intervals of not less than 30 s between each tilting as follows:

a) the battery shall be tilted through 45° from the vertical in a maximum period of 1 s,
b) The battery shall be maintained in this position for 3 s, and

c) The battery shall be returned to the vertical position in a maximum period of 1s.

6.8.3 Throughout the tests described in **6.8.2**, the battery must be examined for any sign of electrolyte leaking from the battery. The observations shall be recorded.

6.8.4 *Requirement* (*see* **7**).

6.9 Robustness of Handles

6.9.1 The handles shall be such that they cannot be detached accidentally from the battery during use or handling.

6.9.2 A load equal to twice the weight of the battery filled with electrolyte is attached to one handle and the other handle shall be lifted with a lifting device to a height of one mter with a speed of 0.2 m/s followed by smooth lowering. The process shall be repeated for 5 times.

6.9.3 Then battery shall be left hanging for 1 h.

6.9.4 After the test no bending or breaking of the handles shall be obverted.

6.10 Residual Capacity Test (for Batteries Received in Filled and Charged Condition)

6.10.1 The battery shall be discharged with the constant current Is down to a final discharges voltage of 9.0 V per battery. The capacity shall be measured at 27 ± 2°C.

6.10.2 The test is carried out to bring the battery in definite state of charge. The battery voltage during the discharge and the capacity obtained shall be evaluated for information whether the battery is electrically in order.

6.10.3 Required residual capacity shall be 65 percent minimum of rated capacity.

7 REQUIREMENTS

The requirements applicable to essential functional characteristics are summarized in Table 4.

Table 4 Summary of Requirements

(*Clause* 7)

Functional Characteristics	Requirements	Comments
20 h capacity (**6.1**)	$C_e \geq C_n$	For batteries rated in Ah
Reserve capacity (**6.2**)	$C_{r\,e} \geq C_{r\,n}$	For batteries rated in Reserve capacity
Cranking performance test (**6.3**)	$U_{10s} \geq 7.5$ V	Compulsory
–18°C or –29°C (if specified)	$U_{30s} \geq 7.2$ V	Compulsory
	t_6 V ≥ 40 s	Optional
	Total time ≥ 90s = (30/0.6 s + 40 s)	
Charge acceptance (**6.4**)	$I_{ca} \geq 2I_o$	
Charge retention (**6.5**)	$U_{30s} \geq 8.0$ V	
Endurance (**6.6**)	Number of units = 4	
Corrosion test (**6.6.1**)		
Cycling test 1 (**6.6.2**)	Number of cycles = 120	Or higher if specified
Cycling test 2 (**6.6.3**)	Number of units = 5	Or higher if specified
Cycling test 3 (40°C and 75°C) (**6.6.4**)	Number of cycles = 34 × *C*r, n – 581[1)]	Or higher if specified
Vibration (**6.7**)	$U_{30s} \geq 7.2$ V	
Electrolyte retention (**6.8**)	No evidence of liquid on the vent plugs.	
Robustness of Handles (**6.9**)	No bending or breaking of the handles shall be observed	
Residual Capacity Test (for batteries received in filled and charged condition) (**6.10**)	Required residual capacity shall be 65 percent minimum of rated capacity	

For both C_e or $C_{r\,e}$ and the cranking performance, the specified values shall be met in at least one of the three relevant discharges above (*see* **6.1**, **6.2**, and **6.3**)

[1)] This formula applies for C_r from 40 min to 150 min.

ANNEX A

(normative)

CORRELATION BETWEEN C_n AND $C_{r,n}$

(*Clause* 4.1.2)

The value of $C_{r,n}$ (in minutes) may be estimated from C_n (in ampere hours) using the following equation:

$$C_{r,n} = \beta (C_n)^{\alpha}$$

where

α = 1.120 1

β = 1.133 9

Reciprocal equation:

$$C_n = \delta (C_{r,n})^{\gamma}$$

where

γ = 0.892 8

δ = 0.893 9

ANNEX B

(normative)

SAFETY LABELLING

B-1 DEFINITION OF THE SIX COLORED SYMBOLS

The symbols mentioned in **3.1.5** are shown in Fig.1:

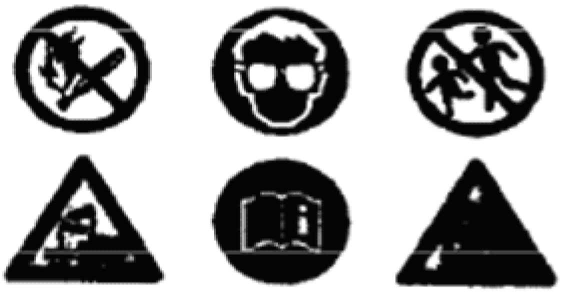

FIG. 1 SYMBOLS FOR SAFETY LABELLING

The symbols shall have common dimensions as shown in Fig. 2 with a minimum dimension of 10 mm.

The symbols shall be located in a group on the top of the battery (as shown for example in Fig.1).

No text in any language shall be included with the 6 symbol block.

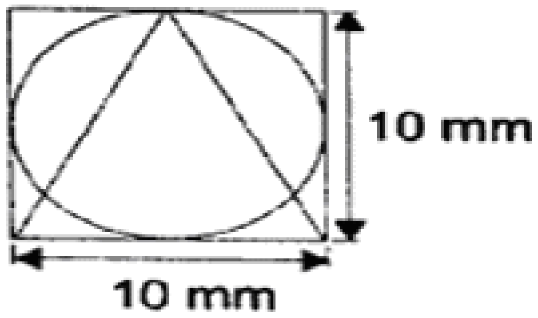

FIG. 2 DIMENSIONS FOR SYMBOLS IN SAFETY LABELLING

The meaning of the 6 symbols is given by ISO standards

The meaning of the symbols are as follows:

(RED)	No smoking, no naked flames, no sparks
(BLUE)	Shield eyes
(RED)	Keep away from children
(YELLOW)	Battery acid
(BLUE)	Note operating instructions
(YELLOW)	Explosive gas

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